

# Creation and Implementation of a Municipal Science, Technology and Innovation System - An Experience Report

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**Abstract**— Science, Technology and Innovation (ST&I) has the power to disrupt the old and consolidated political, social, cultural and economic paradigms of society. For effective ST&I actions to take place in a society, the participation of the business sector, ST&I institutions and, above all, the constituted public administration is necessary. This experience report aims to describe the process used to create and implement the ST&I municipal system. A case study was carried out in Campina Grande, one of the largest and most developed municipalities in the interior of Brazil. The results of the study indicate that the integration between the public administration, business and academic sector as well as the effective participation of the ST&I institutions was essential for the creation of a legal ordering for ST&I that would meet the specificities of the municipality in question.

**Keywords**— ST&I Municipal System. Public policies. Innovation Process. ST&I Laws and Regulations.

## I. INTRODUCTION

The technoscience revolution has caused a rupture or discontinuity over the old and consolidated political, social, cultural and economic paradigms of society. There is a change of mindset with greater engagement among people; business and academic sector, public administration with the purpose of improve the old paradigms, not only for raising economic gains, but for social inclusion through science, technology and innovation. This mindset change requires the individual citizen, the public power, and the private sector, as agents of social transformation, each one with its own rights and responsibilities, to change the mindset for achieving the goals of a ST&I-based society.

Assuming every agent of transformation must act according to their possibilities, we have that the public administration, in agreement to Brazilian law, must act according to the legal permissions. Therefore, there must necessarily be normative instruments that support its action and the use of public resources for this purpose, observing the reality of the state that has the tools for greater reach and impact of public policies for the development ST&I.

Therefore, considering daily life and business are developed within the municipalities, it is within this *locus* that these new practices must be implemented to develop the objectives pursued with this new society. In this scenario, the presence of the public administration as an agent of integration, promotion and development of ST&I. Accordingly, based on the Brazilian constitutional principle of legality, it is necessary to establish a legal ordering that enables multiple municipal agencies to act effectively in the ST&I area.

Observing for this reality and the need for legal ordering, the Complementary Law 141/2018, which instituted the “Municipal Policy of Science, Technology and Innovation” (a.k.a. ST&I Municipal System), was submitted to the Municipal Council of Campina Grande, one of more important city of Paraíba state as well as the northeast region of Brazil. This Complementary Law establishes incentive for innovation, scientific and technological development. Therefore, this law will consolidate itself as an instrument of the public administration action for the integration of ST&I environment in the academic, business and social institutions of the aforementioned municipality.

Starting from the motivation to transform the reality of Campina Grande through development of ST&I, the legal ordering started from a proposal to create a municipal fund aimed at financing projects of this nature. However, during the construction process, the initial legal ordering was expanded to allow the public administration to act more effectively in ST&I area. Actions as the management of this financial fund, establishment of partnerships with educational and research institutions, perform technology orders by the private sector, and transform the developed science in innovation for the life of the population.

The present study aims to demonstrate the collaborative process for construction of the legal ordering, as well as the legal instruments to implement this ST&I incentive policy. It is noteworthy there was an integrated effort by ST&I institutions, academic and business institutions, as well as the population to construct and implement the ST&I municipal system. We believe actions of this nature can contribute to the development of ST&I in this important Brazilian city. Campina Grande can effectively consolidate its role as a promoter of regional development, thus contributing not only to the improvement of its productive and academic sector as well as of all the municipalities which are part of its region.

Based on the inductive scientific method, the study was supported by a broad bibliographic review of references in ST&I area, as it seeks to conclude with the study, based on theoretical and practical assumptions (which is the very experience of elaboration and implementation of legislation in the municipality of Campina Grande) the impact of such a legal ordering at the municipal and regional level.

The remainder of this paper is organized as follows. **Section 2** introduces basic concepts required to understand the experience report described in our study. Related work is discussed briefly in **Section 3**. Settings for construction of the legal ordering are described in **Section 4**. In **Section 5**, we present the main components of ST&I municipal system as well as the conceptualization and details of each of them. The main threats to validity observed in our study are discussed in **Section 6**. Finally, we present our conclusions and point out directions for future work in **Section 7**.

## II. BACKGROUND

This section presents essential concepts related to ST&I as well as the Brazilian legal system in this area.

### 2.1 Innovation in Brazil in a World Context

In research by Cornell University and the World Intellectual Property Organization (WIPO), Brazil ranked 61st in the Global Innovation Index [1]. This index is based on seven pillars, five of which capture elements of the national economy that enable innovative activities: 1) institutions; 2) human capital and research; 3) infrastructure; 4) market sophistication; and 5) business sophistication. The other two pillars, in turn, capture real evidence of innovation outcomes: 6) knowledge and technological results, and 7) creative results.

The **Figure 1** provides a comparison of the seven pillars used to measure the Global Innovation Index between Brazil, countries with similar R&D expenditures, and China. Brazil occupied the 76th position in that same year. According to the 2014 report, all BRICS countries (with the exception of South Africa) were rated as 'efficient innovators', meaning they obtained innovation efficiency scores (calculated as the ratio of total innovation outputs and total innovation inputs) greater than or equal to an average of 0.74.

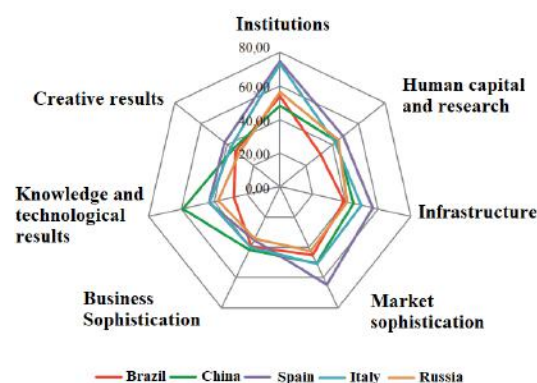


Fig.1. Innovation indicators in selected countries.

When considering all indicators analyzed, the quality of Brazilian universities deserves highlighting. This indicator is calculated as the average of the three best ranked universities in the country in the QS University Ranking. According to this criterion, Brazil obtained 23rd place in terms of quality of universities. Other criteria were analyzed and then we will demonstrate Brazil's position in each of them: high-tech manufactures (21st place), number of firms offering formal training (20th place; indicator where Brazil achieved its best placement), absorption of knowledge (25th place), and the H-index of cited documents (22nd place). Thus we can notice advances in several areas.

On the other hand, it is noteworthy the poor performance of Brazil in the 'business environment' indicator, in which the country was ranked 137th out of the 143 countries studied. This indicator consists of three sub-indicators: *ease of starting a business* (136th place),

*ease of insolvency proceedings* (117th place), and finally, *ease of paying taxes* (131th place). It is evident this is an area that demands more public administration attention, whose role would be to create mechanisms to reduce the bureaucracy involved in the process of opening, maintaining and closing companies in the country.

We clearly note Brazil has advanced significantly in some areas within the context of science, technology and innovation. However, in many others the Brazilian people still lack many initiatives by the public administration as well as private initiative. To improve all these indicators, we need massive investment to create good conditions for the economic and especially social development of the Brazilian people. In the following, we will revisit the main initiatives in terms of research and development (R&D) investments in Brazil in the recent past.

## 2.2 R&D Investment in Brazil

Investments in R&D are of enormous importance for economic and social development [2]. These investments are responsible for developing the knowledge stock of organizations, and also have the function of identifying technological opportunities to be explored, both internally and externally to the organization [3]. In addition, R&D investments are positively related to the performance of organizations [4] and positively impact their innovative capacity [5].

Historically the amount of resources invested in R&D in Brazil is increasing. In 2013, the country invested an amount 84% higher compared to the amount invested in 2000. However, considering this was a period of significant growth of the Brazilian economy, it is clear the increase in expenditures in R&D as a percentage of GDP was much more modest, but also positive [2]. This indicator went from 1.04% in 2000 to 1.24% in 2013 [6], not yet meeting the 1.5% target set for 2010 in the Science, Technology and Innovation Action Plan (PACTI) [7].

The aforementioned plan aimed at “giving greater governance and articulation to the actions necessary for the development and strengthening of ST&I” in Brazil [7]. Among its goals for 2010, it was also the expansion of corporate participation in total R&D investments in Brazil, which should rise from 0.49% in 2006 to 0.65%. However, this target has not been met so far, as the private sector R&D intensity (percentage of GDP invested in R&D) in Brazil that year was 0.57%, falling to 0.52% in 2013. Aims to continue and deepen the PACTI, the federal government launched in 2012 the National Strategy for ST&I (ENCTI) [8]. This initiative highlights the importance of ST&I as a structuring axis for the country's development, establishing guidelines for the

orientation of national and regional actions in the 2012-2015 timeframe [2].

If the R&D growth rate continues over the next few years, it will still take about 20 years to reach the level currently observed in European countries [2]. Compared to developed nations, investments in R&D in Brazil seem quite modest. In 2013 [6] Germany invested 2.85% of its GDP in R&D, while the United States invested 2.73% and China 2.08%. The market share of Brazilian companies in R&D investments (declining since 2005, when it reached 52.3%) represented, in 2013, only 42.3% of total expenditure [6], while in more developed countries 70% of these investments are made by private companies [9].

The lack of coordination between government, companies and universities has historically been one of the main characteristics of the Brazilian ST&I system. However, much progress has been made since the 1980s, due to government initiatives aimed at bringing the academic, public and private spheres closer together [10]. However, according to the **figure 1**, we realize the Brazilian scenario of ST&I have improved particularly in recent years. Such improvement was due to the creation of a federal legal ordering that significantly fostered ST&I initiatives. In the following section we will discuss the main government actions in this regard.

## 2.3 Legal Brands - Federal Laws

Investment in ST&I culminates in the growth of countries [12]. For doing so, the Brazilian public administration has been trying to intensify actions to foster an environment conducive to innovation in industry and academia, seeking to encourage the internalization of the culture of research and innovation in companies, the public service, and society in general [7]. To this end, it has created mechanisms over the last few years to promote and encourage research, development and innovation activities.

The Technological Innovation Law [13] played a key role in this process. Promulgated in December 2004, it created incentives for scientific and technological innovation in a productive environment, seeking technological autonomy and industrial development for Brazil. This law was fundamental in defining the types of cooperation agreements that could be signed between universities and companies. In its 16th article, this law establishes every scientific, technological and innovative institution (STII) must have a Technological Innovation Center, own or in association with other STII, in order to manage its innovation policy.

Decreed in November 2005, “Lei do Bem” (in English, *law of good*) granted a set of tax incentives to

companies to conduct R&D aiming at technological innovation [11]. These incentives include: the deduction of up to 34% in *Corporate Income Tax* and *Social Contribution* on Net Income from investments in technological R&D of technological innovation; 50% reduction in the *Taxes over industrialized products* (IPI) on the purchase of R&D machines; and the *economic grant*, through science and technology promotion agencies, of masters or doctors employed in technological innovation activities in companies located in Brazil [11][12][13].

The Informatics Law, initially enacted in 1991 and improved at the end of 2004, grants tax incentives to companies operating in the areas of hardware and automation that invest in R&D [7]. These incentives are foreseen until the present year of 2019 and refer to the reduction of the IPI for computer components, automation and telecommunications produced in all regions of the country, except the Manaus Free Zone (i.e. special economic zone located in northern Brazil, state of Amazonas), which has specific legislation [11][14].

The aforementioned laws are examples of public administration actions to build an environment conducive to the promotion of ST&I-related activities in both the industrial and academic sectors. However, legal ordering is important, but often not enough. There is also often a need to change the culture and mindset of the actors involved in the ST&I development process. Example of actors are researchers, entrepreneurs, representatives of educational and research institutions, and public administration employees. This requires time and effort. In this context, there is the notion of ST&I systems and ecosystems, which arise from the union between public and private administration with a view to fostering and promoting technological development between the actors and society. Although these concepts seem synonymous, there are substantial differences between them. In the following section, we list in detail the concepts associated with ST&I systems and ecosystems.

#### 2.4 ST&I Systems and Ecosystems

The concept of ST&I system is older, created in the 80's by Freeman [15]. In fact, this approach was created to replace the theory that understood ST&I activities as a linear process and no longer addressed all the complexity that surrounds the process. Therefore, the concept of ST&I system arises from the perception that technological development activities form a complex process, resulting from the interaction of several actors, mainly institutional ones.

According to Freeman and Soete [15], **ST&I systems** are formed by the various interactions, analyzed in a

broad sense, between public and private agents dealing with Science, Technology and Innovation, as well as the teaching and diffusion of technology. Similarly, Nelson and Rosenberg [33] cite that ST&I systems are a set of institutions whose interactions determine the innovative performance of national companies.

In addition, it is worth mentioning there are different configurations of ST&I systems: *national system*, *regional system*, *state system* and, finally, *municipal system*. Therefore, the national ST&I system considers the entire institutional, legal and policy framework of the country. We can say that the national system arises from the union of all regional systems. Regional systems arise from the union of state systems and so on.

In the following section, we will expose some of the main details associated with the Brazilian ST&I system. Consequently, the state and municipal ST&I systems will be characterized by the geographical proximity of its actors. This type of system has a smaller granularity in terms of geographical dimension. Finally, the *sectoral ST&I system* is concentrated on a specific sector of activity. This type of system does not take into account the geographical dimension for classification purposes.

On the other hand, the concept of **ST&I ecosystem** is newer and derives from the analogy with the biological ecosystem. In such a way, the metaphor was introduced by James Moore in 1993, suggesting that companies should be considered as part of a business ecosystem that involves a number of industries and no longer as units of a single industry. According to Lemos [16], the term ecosystem is widely used in management and economic discourse in order to describe heterogeneous groups of actors who work cooperatively and interdependently. Similarly, Jishnu, Gılhotra and Mishra [17] and Russell et al. [18] report the ST&I ecosystem refers to the inter-organizational, political, economic, environmental and technological systems of ST&I, where catalyzing, sustaining and supporting business growth occurs.

According to Mercan and Göktaş [19], the approach to ST&I systems does not explain the relationship between the innovation process and the innovative structure. Therefore, due to the static nature of the ST&I system model, the biology-based ecosystem approach was created. The ST&I Ecosystem considers the dynamic nature of ST&I activities. The concept describes the evolutionary characteristics of interactions between actors, their relationships with ST&I activities and their relationships with the environment in which they operate. The authors Russo-Spena, Tregua and Bifulco [20] differentiate the two concepts as follows in **table 1** described below.

Table 1. Main differences between ST&amp;I system and ST&amp;I ecosystem.

		ST&I System	ST&I Ecosystem
<b>Community of scholars</b>		Politics; economics; Innovation Economics	Technologic innovation; Strategy and business; Economics and regional studies; Entrepreneurship
<b>Core Concepts Set</b>	<b>Innovation</b>	Analyzing and Explaining Changes in Technology and Economic Growth	Understand the dynamics within companies and in the network of economic and social innovation activities
	<b>Context</b>	Limited in a specific geographic area or industry	It is neither fictional nor industrial, but considered emerging and self-regulating, similar to a platform that provides modular resource structures for innovation.
	<b>Actors</b>	Interacting economic, business and institutional actors, but maintaining their autonomy	Interaction of interdependent business, economics and institutional parties; more attention to peripheral and distant relations
	<b>Facilitators</b>	Knowledge and learning favored by the institutions	Knowledge and technology blended and driven in a balanced approach based on cross -fertilization
	<b>Governance</b>	Path dependent nature with a crucial role played by institutions	Resulting from the interaction of deliberate and unforeseen business-led processes through a dialectical process of negotiation
<b>Main ontological position</b>		Complicated set of diverse actors, connecting within a set of predictable interactions aimed at balancing and depending on clear and established rules	Complex set with several actors, but with multiple unpredictable interactions, mediated by knowledge, in a state of imbalance. Rules are adjusted over time and based on tolerance of imbalance to convey innovation

As demonstrated, both concepts work with the interaction of various actors to promote ST&I activities. Therefore, in a more macro sense, ST&I systems are more formalized structures, often contained in law, eg Article 219 of the Federal Constitution provides for the country's National Science, Technology and Innovation System (SNCTI), with the aim of formalize the interaction between public and private entities to develop Brazilian ST&I activities. Thus, they represent the direct and indirect interaction of larger institutions, such as universities, public administration and companies. Soares [2] states that without a correct legal ordering of ST&I systems, the emergence and maintenance of ST&I ecosystems is not possible. In the following section we will trace in greater detail the emergence of SNCTI as well as its trajectory in terms of actions for development of ST&I in Brazil.

## 2.5 ST&I Brazilian System

There are several trajectories of evolution of the SNCTIs. These trajectories are directly related to the development strategies that each country adopts, and it is up to National Governments to play a leading role in articulating the constituent components of each ST&I system. On the other hand, private investments are fundamental for scientific and technological development, as observed in world statistics on R & D contributions. In this scenario, it is evident the evolution trajectories of the SNCTIs are those that strive for the continuous integration of government policies with business strategies. In addition to integration, we should highlight the expansion and consolidation of systems as fundamental processes that demand increasing efforts of managers dealing with the theme. In a context of globalization, public policies and private initiatives from developing countries have been oriented towards shaping



pairing paths based on both cooperation and international competition.

The evolution trajectory of the Brazilian SNCTI is marked by the country's need for pairing with the world's most advanced ST&I systems [2]. According to **section 3.2** of this paper, we realize large investments have been made in recent years to accelerate national scientific and technological development, leading Brazil to stand out in various sectors of ST&I. The main actors in this system are the ST&I Institutions, public management entities at all levels (i.e. federal, state and municipal) and companies.

Many actors make up the SNCTI, some with broader levels of action, others with more restricted functions in the system functioning. Several roles must be played by these actors: making strategic decisions, operating

instruments, conducting research, designing programs, and more [2]. It is up to the political actors to define strategic guidelines that will guide the initiatives of the ST&I System. The decision-making of these actors derives both from the results of representative democracy (Executive and Legislative Powers), and from the choices made within the sectoral representation entities (entrepreneurs, workers and researchers). The funding agencies are in charge of mastering the instruments that will enable the decisions made by the political actors. System operators are responsible for carrying out the planned R&D activities. The representation of this frame of actors is shown the **figure 2** described below.

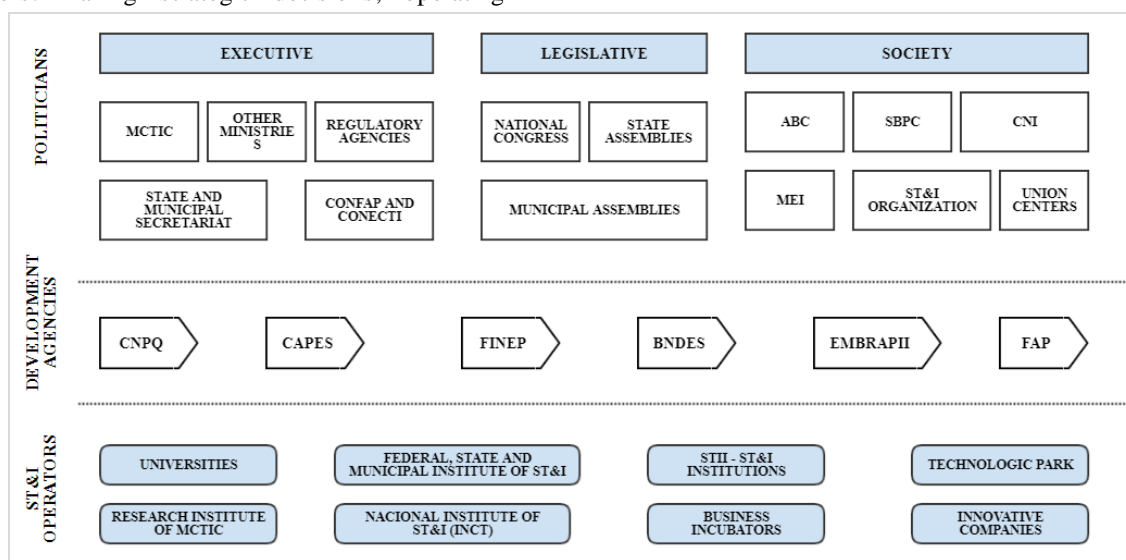


Fig.2. Main components of Brazilian ST&I system.

Within the scope of the executive power, the performance of the State Secretariats of ST&I, which act as Regional Systems Coordinators, should also be highlighted. There are two instances of regional representation that deserve special mention: the National Council of State Secretaries for Science, Technology and Innovation Affairs (Consecti) and the National Council of State Research Supporting Foundations (Confap). These two instances are presented as forums for the articulation of State Governments policies aimed at scientific and technological development. Several joint initiatives have been undertaken involving federal, state and municipal actors, with the continued maturation of these relationships in favor of improving the SNCTI. The “carta de Salvador” (2004) reflects the advancement of cooperation among Brazilian states, considering the need to correct regional inequalities in the conduct of ST&I policies.

### III. RELATED WORK

According to describe so far, this paper aims to narrate the authors' experiences in the process of creation and implementation of a municipal ST&I system. Therefore, this theme has received great attention from the last decade. For purposes of analysis of work related to the present, we will be limited only to works performed in Brazil and in cities which have characteristics similar to the municipality of Campina Grande (e.g. number of inhabitants, geographical area, economy, culture and installed infrastructure). Such decision aims only to reduce the universe of works as well as to better structure the information.

The creation of specific agencies for the ST&I sector within the administrative structures of the Brazilian states is based on the pioneering experience of the state of São Paulo [21]. The São Paulo constitution of 1947 already provided for the support of scientific research and the

creation of a foundation for this purpose. This project was held in that Assembly from 1948 and resulted in the establishment of the São Paulo State Research Support Foundation (FAPESP) in 1962. The work of Junckes *et al* [22] shows that from this pioneering initiative, many other states followed the same action. This study presented the position of Brazil in relation to ST&I activities, identifying the performance of Brazilian states in policies for articulation and integration of their activities. In 2016, the authors claimed there were 18 states in all regions of the country with legal ordering aims at promoting ST&I, as well as three other states with legal ordering pending. Some establish ST&I systems based on the *Triple Helix Concept*.

At the municipal level, the city of Vitoria (Capital of Santa Catarina State) was the pioneer in establishing a municipal ST&I system [21]. In December 1991, a law that created the Municipal Council of Science and Technology - in addition to the Support Fund for Science and Technology of the Municipality of Vitoria (FACITEC) - was sanctioned. The system was comprised of secretary, council and fund and it was created to strengthen the local science and technology activities. Similar to what happened with the state of São Paulo, this initiative at the municipal level spread to other regions, so that in 2012 there were more than 150 municipal ST&I systems, distributed across 21 Brazilian states: São Paulo (30), Mato Grosso do Sul (28), Minas Gerais (14), Rio de Janeiro (10) and Santa Catarina (8) have the largest number of cities with municipal ST&I systems. A more detailed list can be found in the paper by Fonseca [23].

Analyzing works of municipal ST&I systems related to municipalities with similar characteristics to Campina Grande, we have the work of [24]. In this paper, the author and colleagues carried out a study aimed at building a municipal ST&I policy to operate between 2015 and 2025. For the preparation of this plan, the guiding question of the planning exercise was: "How will Campinas, a city of knowledge and innovation, in 2025?". From it, a series of discussions were held in different forums with representatives of the public administration, universities and ST&I institutions. The first step in the construction of the ST&I Strategic Planning was the definition of local strategic drivers by an analytical committee composed of fifteen people, these being the most relevant drivers of the local ST&I policy. The process also included stages in which the vision was elaborated, the SWOT matrix contemplating the strengths, weaknesses, opportunities and threats for the city, the formulation of strategies, definition of indicators and goals.

Other related work [25] presents the definition of the overview for the promotion of ST&I activities in Santa Catarina (Brazilian State) from the identification and analysis of existing ST&I legal ordering within the municipalities, in convergence with the state and federal laws, especially in relation to the Legal Framework of Innovation. The study reveals the existence of municipal ST&I systems, besides the creation of councils and funds that deal with the subject. The search resulted in the identification of *three ordinary laws* and *two complementary laws* within the established parameters, for five municipalities: Araranguá, Chapecó, Florianópolis, Joinville and Luzerna. The municipal ST&I systems are composed according to the triple helix model, and complying with the Federal Constitution and the Legal Framework regarding the responsibility of the public administration in all spheres of promotion of ST&I aims to regional socioeconomic development.

Finally, there are some studies applying case studies in municipalities with the purpose of merely providing an overview of the municipal ST&I system, but without conducting an in-depth analysis on the creation and implementation of a legal ordering to standardize the ST&I actions in the municipality. The work [26] makes an analysis of the innovation system of the municipality of Guarulhos (a municipality of São Paulo State) and performed a comparative analysis with other French municipalities in order to point out the improvements to be implemented in Brazil.

#### IV. CONSTRUCTION OF THE LAW

This section presents the main concepts related to execution of this research. The details related to the scientific method, the activities and procedures for creating and implementing the ST&I municipal system are described below.

To understand the breadth and scope of this legal ordering (i.e. ST&I municipal system), it is necessary to observe material and motivational aspects for your proposition. The project has its origin in the discipline of Science, Technology and Regional Development of the Postgraduate Program in Regional Development of the State University of Paraíba (UEPB). The chair of this class provoked his students and, among the students of this class, there was a city councilman who was underwriting one project to create a Science, Technology and Innovation Fund. This fund aiming at sponsor solutions to the city's problems through R&D projects developed by academic and business sector. After a series of brainstorming with the teacher and students of this discipline, in August 2017, a public hearing was held at

the Campina Grande City Council [27]. This public hearing was convened to discuss with the various municipal ST&I actors (e.g. ST&I institutions, universities as well as business sector) the need to create a legal ordering aims to implement a municipal ST&I system.

Immediately after the public hearing, a "workgroup" was created to provide technical and legal advice on the drafting of the legal system regarding municipal ST&I system. The working group consisted of about 8 people from different institutions. These people had different academic backgrounds and different professional experiences in the ST&I area. This multidisciplinary nature of the "workgroup" greatly facilitated the drafting of the legal system in question. Following the principle of collaborative building, the workgroup met many times, most of them with different guests, including representing of the state and federal public administration. After long discussions, it was concluded that the Fund should be supported by a broader legal ordering. At this point, the working group suggests the creation of a broader legal framework that, in addition to the municipal ST&I fund, would address the need for the establishment of a municipal ST&I system.

Following this change of perspective then arises the need for broad discussion among the various municipal ST&I actors. In addition, it is also necessary to consult the general population about the creation and implementation of the ST&I system. These discussions took place for about a year, being organized by the workgroup and held at various municipal ST&I institutions. The final outcome of this process was officially presented only in July 2018. After regular processing in the Campina Grande Municipal Council and some amendments to suitability, the project was approved only in December 2018. The **section IV.4** will further demonstrate details about all the steps performed in the process of creation and implementation of ST&I municipal system of Campina Grande.

#### 4.1 The Municipality of Campina Grande

Campina Grande is one of the most important municipalities in the interior of Brazil, located in Paraíba State [28]. According to the American magazine Newsweek [29], this city was considered one of the main industrial centers of the Northeast Region as well as the main technological center of Latin America. The municipality's geographical position favors and contributes to its being a natural regional center for the distribution and reception of raw materials and labor among border states, with proximity to capitals such as

Natal (Rio Grande do Norte state), João Pessoa (Paraíba state) and Recife (Pernambuco state).

According to estimates by the Brazilian Institute of Geography and Statistics (IBGE) [30], its estimated population is around 410.000 inhabitants, being the second most populous city in Paraíba state. When considering its metropolitan region, made up of nineteen municipalities, it has an estimated population of 640.000 inhabitants [30]. Having an estimated Gross Domestic Product (GDP), for 2015, more than 5 billion of reais, the second largest in the Paraíba state.

The main economic activities developed within the municipality are, by sector: (i) *Primary Sector*: mineral extraction, agricultural crops (highlighting the cultivation of common cotton and colored cotton - technology developed in the municipality and used worldwide) and livestock; (ii) *Secondary Sector*: manufacturing industries (highlighting the footwear industry, one of the largest in Brazil), hardware and software development; (iii) *Tertiary Sector*: retail trade, wholesaler and services.

Additionally, the city is an important university center, with 21 colleges and universities, three of them being public ones. It is also the city with, proportionally, the largest number of persons with PhD degree in Brazil, 1 to 590 inhabitants, representing about six times the national average [31]. Besides to higher education, the municipality is also featured in training centers for secondary and technical level. An evidence of the city's development is the ranking of the magazine "Você S/A" (an important Brazilian magazine in business area), which appears as one of the 100 best cities to work and career in Brazil, the only inland city among the chosen capitals in the country. The city is still considered the most dynamic city in the Northeast and the 6th in Brazil according to "The Gazeta Mercantil" (other important Brazilian magazine in business area) and was named as one of the 20 Brazilian metropolises of the future [32].

#### 4.2 Internal and External Environment Analysis

The analysis of the internal and external environments in which Campina Grande is inserted can be extremely important for the formulation of strategies and action plans for the ST&I area. This analysis raises the political, legal, technological, economic and sociocultural forces that positively or negatively impact the creation and, subsequent implementation of the municipal ST&I system. For this analysis we used the SWOT Matrix, which stands for the terms Strengths, Weaknesses, Opportunities and Threats.

The Matrix is an instrument used for strategic planning, which allows collecting information that



characterizes the **internal** (*strengths and weaknesses*) and **external** (*opportunities and threats*) environments, relevant to the planning process and to the execution of the plan. The purpose of the SWOT is enabling an objective and critical look at the opportunities, threats, strengths and weaknesses that the municipality has.

Table 2. Strengths and weaknesses

Strengths	Weaknesses
1) Good level of communication between the main development agents. 2) Diverse and well-structured trade. 3) Significant and consolidated set of diversified R&D Institutions (Agribusiness, ICT, etc.). Quality higher education. 4) Easy access (highways, railways and airports). 5) Important regional attraction pole. 6) Existing urban infrastructure. 7) Qualified labor. 8) Diversified industrial park with presence of important global players. 9) Expressive scientific and technological production. 10) Recognized as a city of science, technology and innovation.	1) Long-term view of the Municipal Secretariat for Economic, Social and Tourism Development. 2) High cost of local labor. 3) Lack of a consistent long term strategic plan for ST&I. 4) Absence of a program to stimulate the culture of citizenship and the sense of belonging. 5) Absence of culture of innovative entrepreneurship. 6) Low performance of the productive sector (companies) in ST&I. 7) Low integration between government, productive sector and research institutions to stimulate the use of ST&I. 8) High crime rate. 9) Bureaucratic barriers in municipal land use and occupation legislation. 10) Lack of establishment of neutral governance of the Local Innovation System, with active participation of all key actors. 11) Technical and environmental problems in urban mobility.

In the **internal environment**, it is possible to verify several *strengths*. Campina Grande has a good level of communication and integration between the main ST&I actors of the public and private institutions. It has diversified and well-structured businesses, high-level educational and research institutions capable of meeting the growing needs of skilled labor and generating new

knowledge. The city has (i) a network integrating actors in the ST&I area, (ii) different physical infrastructure and logistics when compared to other Brazilian cities, (iii) diversified industrial park with the presence of global players, being nationally recognized as a ST&I city.

This aforementioned scenario makes Campina Grande a municipality differentiated from the vast majority of Brazilian cities. In relation to *weaknesses* that may impact or limit its competitiveness as a city of knowledge and innovation, and which should be understood as opportunities for improvement by the municipal administration and other actors involved, the high cost of local labor resides, incipient venture investment culture (e.g. angel investors, venture capital, and venture capital), absence of a culture of innovative entrepreneurship, problems in public safety aggravated by being a metropolis-sized city, restrictions on physical space for the implementation of new technology-based enterprises and problems in urban mobility.

In the **external environment** there are many *opportunities* that may favor the competitiveness and growth of Campina Grande. These include the ability to raise funds for financing and fostering innovative research with financial institutions and funding agencies, the marked growth of the economy in knowledge-intensive sectors in the region, and the privileged geographical location in the central region of Paraíba state. The municipality is undoubtedly a center of attraction for the establishment of public-private partnerships that can boost and enhance the city's growth in both the expansion and consolidation of infrastructure and the provision of services to society.

Table 3. Opportunities and Threats

Opportunities	Threats
1) Fundraising capacity for financing and fostering innovative research with financial institutions and development agencies. 2) Strong economic growth in knowledge-intensive sectors in the region. 3) Entrepreneurship culture in the region. 4) Existence of policies for creation Regional System of Innovation. 5) Incentives for the establishment of	1) High cost of living. 2) Increased public and road insecurity. 3) Competition with other cities with more structured projects to attract technology-based companies. 4) Inadequacy of government projects and policies in the three spheres for ST&I. 5) Complex legislation in all spheres of government. 6) Not establishing the SRI (Regional Innovation System), avoiding

(Public-Private Partnerships).	sustainable consolidation in a network of influence.
6) Geographic localization.	7) Possibility of downgrading the country's rating, driving away foreign investments.
	8) Non-renewal of the law and tax incentives for the ST&I areas

The *threats* may impact the growth and economic, social and environmental development of the municipality are related to the high cost of living in items such as housing, mobility and services, increased public insecurity and bureaucracy. Also weighing in this assessment is competition with other cities with well-structured projects to attract technology-based companies. These are recent threats, posing new challenges for city planning, and the limitation of water availability in the Region and the poor economic performance of the country, with impacts on risk assessment of investments in the country and the region, which may discourage or limit investments by large international groups.

#### 4.3 Motivation for creating the ST&I system

Looking at this data of municipal development, it is clear that the city of Campina Grande has an incipient "ST&I system", being this city a national and international reference in several areas. In addition, there is a considerable structure consisting of several institutions such as Incubators, Accelerators and Fostering Companies and Startups, as well as a Technology Park.

Even with the entire city setting focused on ST&I (described in **section 4.1**), Campina Grande - as well as many other Brazilian municipalities - perish with public policies that effectively enable ST&I development. Given this scenario, the idea of creating a legal ordering to implement a ST&I municipal system arises, which has among its main objectives: (i) The strengthening of the existing "ST&I system"; (ii) Leverage the technical and legal infrastructure for local scientific and technological production; (iii) Encourage sustainable development through ST&I in a productive environment, reversing the benefits to the municipal population and the entire region.

This legislation will also allow it to increase the contribution of public and private resources in ST&I. By creating an area-specific legal ordering, private companies - as well as the municipal public administration - will have more legal certainty to reverse resources in ST&I actions. Another relevant detail with the emergence of the law is associated with the increased promotion of ST&I ecosystems. This will be achieved by

diversifying financial instruments to support ST&I activities, allowing greater sharing of resources between public and private entities.

#### 4.4 Collaborative law-making process

As described in detail at the beginning of **section IV** of this document, the genesis of the debate on ST&I municipal system was the institution of a ST&I Municipal Fund. However, during discussions held at a public hearing, the prospects broadened for the introduction of a broad legal ordering that encourages ST&I development.

In order to address the creation of the legal ordering, the **figure 3** describes the process of creation and implementation of the ST&I municipal system. *Blue colored circles* represent people, ST&I institutions or artifacts generated through this process. The *green circles* represent the publicizing of the artifacts of this process through public hearings. The *red rectangles* represent adjustments in the artifacts of the process by the public and private sector as well as the regulatory agents (i.e. legislative, judicial and executive power).

It is worth noting all the *steps* in this process are numbered so that the numerical sequence makes it clear there is direct dependence between all these steps which will be described following in detail:

**ST&I Legislative Committee (1)** – The ST&I committee is a technical body created by the internal rules of Municipal Council of Campina Grande (MCCG). This committee is composed of elected alderman with active mandate and it has the purpose of discussing and voting on the presented laws. With respect to certain proposals or projects, the committee expresses itself by issuing technical and legal opinions on the subject, by means of opinions, before being taken to the Municipal Council for voting. Regarding other propositions, the committee decides to approve or reject the law without the need for passage through the Municipal Council. The alderman composition of this committee is renewed each year or legislative session. Finally, it is worth noting that the ST&I committee is also formed by a technical professionals that operates in several public and private ST&I-related institutions in the municipality.

**Public hearing at MCCG (2)** – Public hearings make it possible for alderman hearing the opinion of the population on a particular topic. They usually happen before a law is sanctioned. In the Campina Grande's case, these public hearings can be held in the Municipal Council itself or even in the neighborhoods. In addition to alderman, voters and entities, such as entities and companies, may convene hearings. When the hearing is requested, a notice should be published in at least two widely circulated newspapers. It is occurs aiming at

publicizing such action. The alderman can select authorities, experts and interested persons to be heard. When the subject to be discussed has opponents and defenders, several sessions are called so that all parties can be heard. This was the case with this legal ordering. As described in **figure 3**, three public hearings were held to discuss the creation of the municipal ST&I system. All citizens can participate in public hearings, which serve to expose topics or make suggestions for specific subjects. Being a consulting activity, the manifestations occur orally or in writing. In the end, the proposals are sent for analysis by the alderman.

**ST&I Workgroup (3)** – Immediately after the previous step, a “workgroup” was formed to provide technical and legal assistance for the constitution of the

legal ordering. Thus, a representative part of the public and private ST&I institutions installed in the municipality made up this workgroup. Among others, this group had the following main responsibilities: (i) drafting the legal ordering document; (ii) technical and legal advice on operational and legal aspects regarding implementation of ST&I municipal system; (iii) creation and maintenance of communication channels with private and public ST&I institutions and the productive sector of the municipality; (iv) dissemination of the legal ordering in the media as well as in ST&I-related events. It is worth noting that this group was composed by about six people from four different public and private ST&I institution. This workgroup worked for several months providing this advisory work for free and committed.

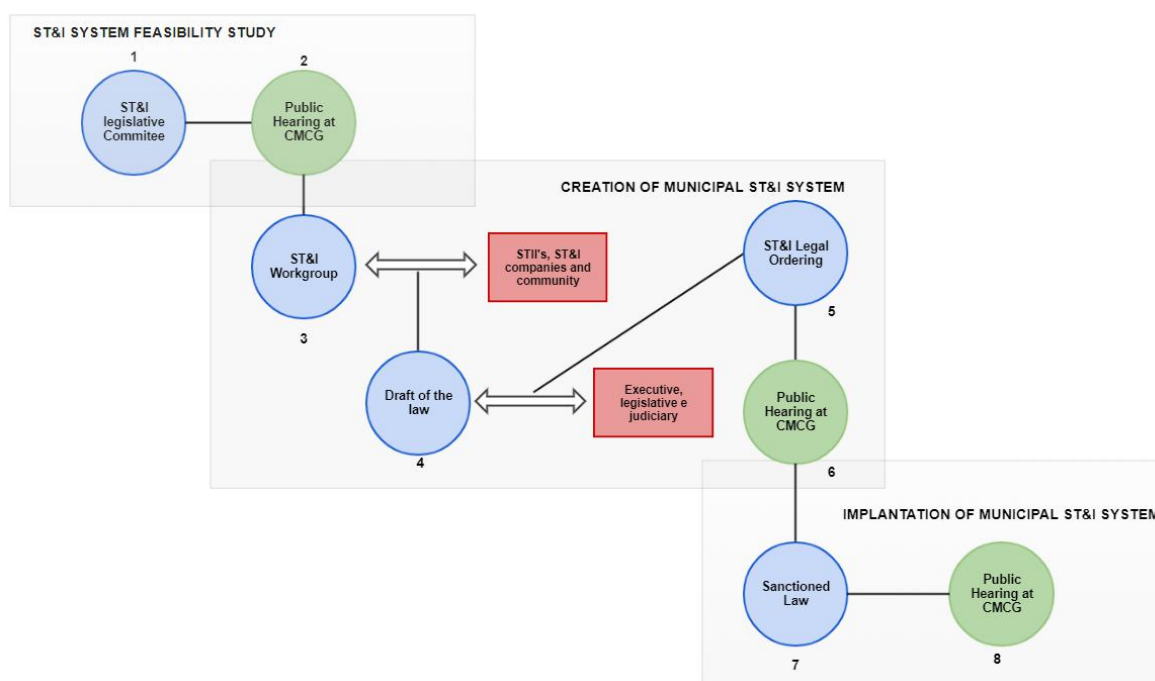


Fig.3. Creation and Implementation Process of ST&I Municipal System.

**Draft of the law (4)** - For the writing of the draft Campina Grande ST&I system, the working group carried out a two-step systematic review on the legal ordering repositories: (i) Firstly, the workgroup retrieved state and federal ST&I-related legal ordering. These legal ordering were analyzed to understand the legal system around ST&I area. In this sense, the workgroup had the support of jurists specializing in the subject, providing effective support to carry out this activity. (ii) Finally, the workgroup retrieved municipal ST&I-related legal ordering of Brazilian municipalities (and also some of North America and Europe) that had similar characteristics to the Campina Grande. Then, the workgroup systematically analyzed the various components of all these ST&I-related legal ordering.

Lastly, the working group deliberated on the feasibility of including / excluding these components in the municipal ST&I system. At the end of this process, a document was generated by the collaboration of workgroup and others independent consultants.

**ST&I legal ordering (5)** - Following the generation of aforementioned document, this one was submitted for the municipal attorney's office. This activity aims to identify possible inconsistencies or even legal flaws. The document was then submitted to the municipal legislature - represented by the ST&I legislative committee - aiming at provides appropriate adjustments to the document. Finally, the document was submitted to the municipal executive power. In this activity it was verified the

technical and economic viability of some of the components of the legal ordering.

**Public hearing at MCCG (6)** - After the generation of a legal ordering document - through an intense and constant series of debates with the community, public and private ST&I-related institution, executive, legislative and judiciary - this document was submitted to the Municipal Council of Campina Grande (MCCG). In a public hearing the document was placed in voting for the alderman, after about two months of appreciating the document, could express their opinion related to legal ordering in question.

**Sanctioned Law (7)** - After the public hearing was held in the municipal council, the result was favorable to sanction by the municipal mayor. A few months after the result of the public hearing, the municipal chamber of the city mayor made the necessary adjustments to implement the components of the ST&I municipal system. In order to comply with the objectives of this legal ordering, the municipal public administration will make efforts to promote the development of scientific, technological and innovator potential of the Municipality, in order to:

I - allow the transfer of financial resources - including by means of refundable - to institutions members of the ST&I Municipal System, in order to develop and manage R&D projects;

II - promote the participation of the municipality in the creation and maintenance of R&D projects focused on innovative activities;

III - participate actively and strategically in risk reduction and distribution technologies involved in the innovative process;

IV - to foster the process of creating innovative enterprises through the facilitation, as appropriate, of procedures for opening and technology base or innovative companies;

V - Contribute to the formation and modernization of local ST&I infrastructure, including by facilitating the sharing or disposal of available public goods; and

VI - promote the broad participation of the local community in the diffusion of scientific culture as well as the formation of an entrepreneurial culture.

**Public hearing at MCCG (8)** - Following the sanction of the legal ordering described in the previous step, the last public hearing at MCCG took place. This activity was basically for the discussion of effective actions to operationalize the main components of the ST&I municipal system. The **section V** will describe in detail the concept as well as the motivation for each of these components.

Constructing the aforementioned legal ordering to create and implement the ST&I municipal system within such a process model, in a collaborative way, represents a paradigm that is in full agreement with the goal of the municipal ST&I policy: to involve the city around an action composed of many actions that is above any partisan political bias and is a policy of state, not government, for the benefit of the community. Moreover, only legal ordering proposals - which are built in a participatory manner - have a real social identity and a sense of ownership.

## V. THE MUNICIPAL LAW OF SCIENCE, TECHNOLOGY AND INNOVATION

The present legal ordering establishes incentive to the ST&I development, aiming at the consolidation of the innovation environments in the academic, productive and social sectors of Campina Grande, as well as to promote the economic, social and environmental development and the improvement of the public services. In order to achieve the objectives of this ST&I system, several components will be constituted to operationalize actions at the municipal level. The main components of this legislation are described in the **figure 4**. The following, we present the key artifacts that make up the ST&I municipal system.

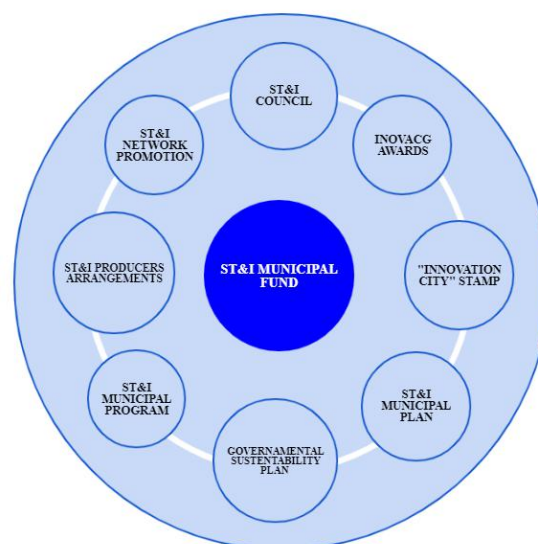


Fig.4. Components of the ST&I Municipal System.

**ST&I Municipal Fund** – This fund is endowed with administrative and financial autonomy, with its own bookkeeping, accordance with the relevant legislation implementing the repayable financial support (or not), innovative programs and projects of interest to the municipality, as well as characterized in accordance with its rules. The main objectives of this fund are to promote:



(i) technological innovation in the Municipality, to encourage companies installed in it, and investments in scientific and technological research; (ii) technological and innovative activities for economic development, Campina Grande's social and environmental program, in the form of programs and projects; and (iii) research, development and innovation activities, with a view to technological, economic, social and environmental development of Campina Grande.

**ST&I Council** - This council is a deliberative body of direct community participation in the municipal administration, which will have the following responsibilities: (i) to formulate, propose and evaluate actions and public policies to promote the innovation for the development of the municipality, through governmental initiatives or in partnership with private agents, always preserving the public interest; (ii) promote the generation, diffusion and democratization of knowledge, information and new techniques, and encourage the introduction and adaptation to local reality of techniques already existing; and (iii) contribute to the ST&I policy to be implemented by the public administration, suggesting fundraising and allocation policies for the purposes of this law.

**INOVACG Awards** - The law institutes the annual "innovate Campina" award. This award aims to reward ST&I-related projects that bring direct benefits to Campina Grande. This award will be managed by the ST&I Council, which will regulate the concession in a specific public notice. This council shall be responsible for regulating the requirements of application of the award, as well as the procedures necessary to carry out the award ceremony.

**"Innovation City" Stamp** - The law establishes the mixed word and figurative mark, which characterizes the "City of Innovation", aims to identifying the participation of the entities that are part of the ST&I municipal System. In addition, this mark will serve to indicate the origin of services and products of the companies of Campina Grande. The mark may be used by companies and organizations participating in the ST&I Municipal System, Innovation Promoting Arrangements accredited by the ST&I Council and other entities authorized by the same Council. In a complementary way, this mark can be used in portals, prospectuses, projections, publications, posters, films and other elements of promotion, dissemination and information.

**ST&I Municipal Plan** - Each municipal organizational unit - the direct or indirect administration - will prepare an Annual ST&I Plan in its responsibility area, which will be presented to the ST&I Council, which

will allocate resources for its execution. This plan will be published, in accordance with the legal ordering, to form partnerships with technology-based companies, research centers and other participants of the municipal ST&I system to promote sustainable development. Finally, this plan will include feasibility studies, projects research, market solution acquisition, solution experiments, performance and impact sciences and research into new solutions to the city's problems.

**Governmental Sustainability Plan** - The municipal organizational units shall develop the Sustainability Plan of its activities. This plan must contain measures and proposals supported by the municipal organizational unit budget for:

- I - the rationalization of the use of natural resources;
- II - social responsibility actions for municipal employees;
- III - energy efficiency actions, investments in clean technologies;
- IV - supply chain optimization;
- V - Preservation of the environment, and recycling;
- VI - respect for human rights;
- VII - protection to human health and ergonomics in the workplace;
- VIII - water preservation, basic sanitation and change in consumption patterns; and
- IX - environmental compensation actions.

**ST&I Municipal Program** - The fiscal incentive through the ST&I municipal program is granted to the individual or legal entity established in the municipality, which is strictly in compliance with its municipal obligations, with the primary objective of promoting innovative entrepreneurship of interest to the municipality. The granting of resources of this "fiscal incentive" can be done by non-repayable financial support, repayable financial support, corporate participation, direct support through fundraising and through economic subsidies.

**ST&I Promoting Arrangements** - The ST&I municipal council will accredit, by own regulation, for the purpose of incentives, the Innovation Promoting Arrangements (IPA's) that are deemed of interest by the municipality. To be entitled to the incentives established by this Law, the applicant should be part of the IPA and accredited by the ST&I municipal council. Systematic information of cadastral and socioeconomic data is a prerequisite for participating in an IPA. These arrangements should meet criteria and be proposed by the ST&I municipal secretariat, approved by the ST&I municipal council and regulated specific ordinance of the municipal public power.



**ST&I network promotion** - This network will be made up of units called Innovation Promotion Offices (IPO). One of which will be deliberative, coordinated ST&I municipal secretariat and many other decentralized through a specific legal instrument, in public or private institutions. This units will constitute a municipal network of institutions engaged in the promotion of ST&I effective actions, in favor of the sustainable development of the municipality. The Municipality may allocate service providers and interns on a regular basis as well as employees at the Innovation Promotion Offices (IPO). The main mission of this network is to (i) support the development of fundraising projects to activities and projects in line with the objectives of this Complementary Law, (ii) propose and implement projects that present themselves as opportunities for development for the municipality and (iii) integrate actions of the Network entities according to the needs of the city.

## VI. THREATS TO VALIDITY

A key concept relevant to a discussion of research methodology is that of validity. There are three types of validity that can be discussed in relation to research and statistics. Thus, when discussing the validity of a study, one must be specific as to which type of validity is under discussion. Each of the three types of validity will be briefly defined and described below. Be aware that this represents a cursory discussion of the concept of validity. Each type of validity has many threats which can pose a problem in a research study. Samples, but not an exhaustive discussion, of threats to each validity will be provided. For a comprehensive discussion of the four types of validity, the threats associated with each type of validity, and additional validity issues see [36][37].

**Internal Validity:** It is the extent to which a piece of evidence supports a claim about cause and effect, within the context of a particular study. It is one of the most important properties of scientific studies, and is an important concept in reasoning about evidence more generally. Internal validity is determined by how well a study can rule out alternative explanations for its findings (usually, sources of systematic error or 'bias') [36]. The main threat of this category is related to the fact that the study represents an experience report. We do not present data or metrics that show the positive impact of lawmaking in any respect (e.g. social, eco-economic or political). Our intention was only to present a formal process for construction and implementation of the law. For this, several actors with different academic and professional backgrounds participated in this process with the aim of reducing any existing bias.

**Construct Validity:** Construct validity is used to determine how well a test measures what it is supposed to measure [36]. In other words, is the test constructed in a way that it successfully tests what it claims to test? Construct validity is usually verified by comparing the test to other tests that measure similar qualities to see how highly correlated the two measures are. In the present development phase of our study, this type of threat is not verified since we simply carry out an "experience report". However, in future work we intend to analyze some data and metrics to assess the impact of law enforcement on the municipality.

**External Validity:** It is the validity of applying the conclusions of a scientific study outside the context of that study [37]. In other words, it is the extent to which the results of a study can be generalized to and across other situations, people, stimuli, and times. The main threat of this category is related to the fact that the study was conducted in a municipality of Paraíba state. Thus state and other municipal laws were taken into consideration for the construction and implementation of the law. If any other municipality in Brazil or even in the world tries to replicate the process described in this experience report, some deviations may be required due to various aspects such as laws, economic, social, political and even cultural characteristics.

## VII. FINAL REMARKS

The present research described the process of creating and implementing a legal ordering aims to establish incentive for ST&I-related activities in the business, academic and social environment. This legal ordering was built on collaborative work. Public and private ST&I-related institutions as well as the general population had wide openness to participate in this process. The main contributions of this experience report are (i) a comprehensive systematic review of the relevant Brazilian ST&I legal ordering, (ii) the formatting of a collaborative process for the creation and implementation of the ST&I municipal system through a proper legal ordering and (ii) the cataloging of an important set of components in a legal ordering for the creation and implementation of a ST&I municipal system.

We expect that the effective implementation of the ST&I municipal system can only occur with proper legal apparatus. This will provide security for public and private institutions to perform activities in the ST&I area. In the specific case of the Campina Grande's ST&I system, their main purposes are the following:

- Promote technological and scientific innovation as a self-sustainable development in the Municipality, for income generation and new business opportunities;
- Stimulate the development of economically viable, socially fair and environmentally sustainable science and technology through government initiatives or in partnerships with private actors;
- Support the interaction between companies, governments and educational institutions, aims to leveraging economic and social development through new science and technology-based business practices;
- Adopt practices of “open innovation” and collective intelligence as a strategy for greater participation of society;
- Encourage the expansion of enterprises, as well as foster the creation and attraction of new projects through the use of financial and tax mechanisms as a development strategy of ST&I activities.

It is important to mention the legislation deals differently with the notion of development, making the city one of the first municipalities in the Brazilian Northeast to have municipal legal ordering that regulates an ST&I system. Additionally, since Campina Grande polarizes a region of dozens of cities, the promotion of ST&I through this regulation will promote regional development as these cities provide and consume products and services from this municipality.

Therefore, such public policy is in line with the various actions related to the innovative proposal on the role of the municipality in stimulating sustainable economic development. Still, components of this legal ordering described in details in this experience report have the objective of modernizing and speeding up the public services from the operationalization of some innovation actions within the public administration.

Finally, more than the technological and scientific progress itself, the legal ordering has as its major scope the elevation of the population's quality of life through the implantation and socialization of technologies developed at the municipal level. Consolidating the municipal and regional economy by creating new business formats, generating new jobs, and encouraging research and science from the earliest stages of the municipal education system. Further details on the construction and implementation of the law can be found in our *supplementary material* (only in Portuguese) [35]. We are available to discuss with the academic community as well as ST&I practitioners all steps described in this experience report.

## ACKNOWLEDGMENTS

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